FIREPLACE AIR SUPPLIES AND GLASS DOORS:
A Literature and Equipment Search

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EXECUTIVE SUMMARY

CMHC has been conducting research into combustion spillage, or the inability of chimneys to properly vent all the products of combustion. The traditional open fireplace not only is likely to spill smoke into the house air, but also often acts as the biggest exhaust device in the house, causing the backdrafting or spillage of the furnace and other appliances.

The most common suggested solution is to isolate the fire air from the air in the house, by installing glass doors and a fresh air intake from the outside. This paper describes a literature and equipment search which attempted to establish how the glass doors and fresh air intakes are specified and designed to meet this objective.

The search through codes, standards, research reports, and miscellaneous articles proves that there is growing awareness of the need for fireplace air separation from house air. Manufacturers are introducing appliances to do this, often causing the traditional fireplace to resemble an airtight woodstove with a glass door. To obtain ULC/CSA "outdoor-aired" certification, the appliances must be tested under severe conditions, and must show no substantial amount of smoke spillage or heating up of adjacent combustible framing. These test procedures are still in development. There is no data readily available on such test results from the certifying agencies or other research organizations. Sizing and location of the fresh air intakes, as specified by code or the manufacturers, appears rudimentary. There is no hard data to favour one design over another.

What has yet to be established is the effectiveness of the designs is keeping fireplace and house air separate, and the safety of these designs under various types of weather, house depressurization, and fireplace construction. This may require extensive laboratory testing.

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INTRODUCTION

The CMHC Research Division has been investigating residential combustion spillage, or the failure of chimneys to properly vent the products of combustion, since 1983. The indoor air quality problems arising from spillage range from long term health effects, due to low levels of pollutants, to death from elevated carbon monoxide levels.

Throughout this research, the open or non-airtight fireplace has emerged as a major problem. A fireplace is among the largest exhaust devices in modern housing, and hence the cause of furnace or DHW backdrafting. The air flow rates of fireplaces can be extracted from the CMHC report "Residential Chimney Backdraft Checklist" (1) or the EMR report "Consumers' Gas Chimney Venting Performance Study" (2), and vary from 30-210 l/s. At low burn, the fireplace itself can spill smoke into the living space, if the room in which it is located is depressurized by any means. A CMHC report, "A Survey of Fireplace Spillage Incidents in Twenty Four Houses" (3), shows that most fireplaces spill frequently, and the householder is often not aware of the smoke (see Table 1). When more airtight houses are being constructed the open fireplace is an even greater anachronism and danger, due to the increased levels of depressurization possible compared to standard housing.

A general recommendation is to provide fireplaces with outside combustion air intakes, and/or glass doors, as a means of keeping the firebox air separate from house air and vice versa. This approach was explored in the CMHC report "Remedial Measures for Wood-burning Fireplaces" (4). This study tested a system of airtight glass doors, heat exchanger, and ducted outside air which was placed into an existing masonry fireplace. Though this retrofit proved effective for that fireplace, it is not necessarily the most cost-effective or householder-preferred solution for all installations.

The types of fireplaces can often be confusing. There are several different varieties mentioned in this report:

1) masonry,
2) masonry with metal liner

Table 1: Results from the CMHC Fireplace Survey (1987)

SPILLAGE FREQUENCY AND DURATION FOR SMOKE AND CO

House Number	Monitoring Period (days)	Number of Fires	Events	Total Duration (minutes)	Average Spill Length (min)
1	91	13	120	55.7	0.46
2	90	17	60	20.2	0.34
3	90	18	9	0.2	0.02
4	87	30	158	88.3	0.56
5	88	73	66	16.8	0.26
6	89	27	610	183.5	0.30
7	85	25	48	6.7	0.14
8	89	26	691	228.3	0.33
9	87	29	254	34.8	0.14
10	82	21	98	33.7	0.34
11	87	19	91	43	0.47
12	83	38	41	139.2	3.39
13	87	24	39	12.7	0.33
14	79	9	21	436.5	20.79
15	85	24	34	5	0.15
16	89	17	204	126.7	0.62
17	94	16	2193	734.5	0.34
18	100	28	98	14.2	0.15
19	100	21	20	49.2	2.46
20	88	23	151	57	0.38
21	90	5	55	31.8	0.58
22	90	11	8	13.8	1.73
23	93	25	249	50.8	0.20
24	88	24	412	202.7	0.49

3) "Zero clearance",
4) insert, and
5) free-standing metal.

Some authorities dislike the term "Zero-clearance" as these metal fireplaces do have clearances to observe from combustibles. These authorities prefer the term "factory-built fireplaces" for type 3 above (5). Fireplace inserts fit inside existing masonry fireplaces, and are effectively woodstoves with large glass doors. Open door operation is not recommended, and these appliances are considered as woodstoves for code purposes. Free-standing metal fireplaces are not enclosed at all, and are generally not dealt with in this paper.

This investigation is to discover the design and use of fresh air intakes and glass doors, as installed or as retrofits, for categories 1,2, and 3 above.

LITERATURE AND EQUIPMENT SEARCH

The nature of this project was to gather information on fireplace outside air intakes and glass doors, from all possible sources. The resulting collection of material is broken into four parts, which correspond to Appendices A-D. A short description of each field of search follows.

A) Codes and Standards

The building code regulations covering fireplaces were examined, and sections describing fresh air intakes for fireplaces were excerpted. The National Building Code, and two provincial codes, were included. Canadian standards concerning fireplaces, from both the Canadian Standards Association and Underwriter's Laboratories of Canada, were perused, and the relevant sections extracted. A guide to builders, from the R-2000 program, has been included in this Appendix.

B) Reports

Seven research reports in this field have been found; three from CMHC, two from Alberta, one from the U.S. Department of Energy, and a 1981 UL report which deals more with fire dangers than with air supplies or glass doors. The Canadian Housing Information Centre searched five databases - CISTI, NTIS, INSPEC 86, EI, and EIM - and did not find any references that dealt with intakes or doors. One Lawrence Berkeley Laboratory report, on energy usage attributed to fireplaces, is still on order.

CMHC has commissioned further work on the fireplace and woodstove simulation program, WOODSIM. This program will be able to model the effects of glass door tightness and fresh air intake sizing on the thermal and flow performance of the fire and chimney. At the time of writing of this report, the final computer program had not been delivered, though progress reports had been promising. Confidence in the predictive capability of WOODSIM will come after analysis of the report, and extensive use of the program itself.

C) Other Publications

This category is a catch-all for any other sources of information. There have been two articles of fireplaces in tighter houses in the CHBA publication, Habitation. Progressive Builder (April 1987) had a substantial "Advertorial" on fireplaces in modern housing. The article "Fresh Air for Fireplaces" comes from that issue, and is the result of an extensive search by the author into fresh air strategies in use. The ULC guide to Fireplaces is shown as an example of recommended practice that is not obscured by the format and language found in standards. The letter and enclosures from R. Carlstrom represent the view of an engineer concerned with investigations of accidental house fires, and the design flaws that he has identified in fireplaces that meet existing standards.

D) Manufacturer's Literature

This selection was garnered from visits to Ottawa fireplace stores, and from literature sent by manufacturers on request. It does not represent an exhaustive search, but should encompass most of the designs currently available. Several fireplace inserts have been included as they seem to have the most innovative air supply methods - which may be copied, in time, by the manufacturers of other factory-built fireplaces.

If readers are aware of research or design work relating to these fields, that have not been uncovered by this literature search, please notify the author about the appropriate references.

RESULTS

The results of the literature and equipment search are split into two parts. Glass doors will be described first, as the information or them is relatively succinct. The design and testing of fresh air intakes comes next.

1) Glass Doors

Although the National, Ontario, and Alberta Building Codes now all address some aspects of the provision of outside combustion air to fireplaces, none attempt to define how this air supply will be dedicated to the fireplace itself, through separation by doors. The standards from ULC and CSA do mention glass door construction, but the airtightness of the doors is only inadvertantly addressed by specifying the level of glass freedom to allow thermal expansion. The tests on glass doors, and additional references in these standards, deal with the type of glass used, its resistance to breakage, the ease of replaceability, and maximum temperature allowed.

The only research paper that attempts to detail glass door leakiness is the study by Scanada Sheltair Consortium (4). These results show that glass doors tested have an effective leakage area of about 100 cm^2, in the same order as the ELA of most fresh air intakes. See Table 2.

The publications warn that reprofitting glass doors on a masonry fireplace could raise firebox temperatures, and lead to a house fire. Appendix 1 in the CMHC project (4) contains several references to this occurrence, and R. Carlstrom brings up the same warning. Another caution concerns the explosion of glass doors if overheated.

Manufacturers do not generally specify or highlight the airtightness of their doors, though the tightness is starting to be mentioned in B.C. (6). The doors on some of the inserts are the size of a small fireplace opening. Since insert doors are designed to operate tightly, it would seem that expense and lack of demand, rather than technology, prevents the manufacturers from offering airtight doors on factory-built fireplaces or for masonry retrofits. Sooting of the glass, and the air wash supposedly required to reduce this sooting, may also be a cause of their reluctance. Both glass explosion and sooting could be avoided if a fine stainless steel mesh screen were used instead of glass, to reduce room airflow into the fireplace. This recommendation comes from Reference 25.

Table 2: Range of ELA's for Typical Airtight Doors

DESCRIPTION	MEASURED ELA	ESTIMATED SPILLAGE FLOW IN TO HOUSE @ 3 Pa (L/s)
New Bifold	84.0 cm^2	9
Used Bifold	123.8 cm^2	14
Used 2-Door	95.7 cm^2	11
New Extra-Tight Energy Efficient Doors	14.0 cm^2	2

2) Fresh Air Intakes to Fireplaces

The title of this section is not necessarily the common term for the duct used to convey outside air to a fireplace. Various publications refer to it in various ways (eg. choose one from Columns A, B, and C below)

A	B	C
Fresh Combustion Outside	Air	Duct Intake

The term "fresh air intake" will be used in this paper despite what terminology is particular to other publications or standards.

This section begins with a few theoretical observations. Some testing was performed in a CMHC spillage research project (Ref. 1) on the amount of window opening that was required to reduce the depressurization of the fireplace room to a safe level. Most houses in that survey required no window openings, but those that had excessive depressurization levels needed relief openings of 20-400 cm^2. Compare these areas to the standard fresh air intake supplied with fireplaces. The 100 mm and 125 mm diameter intakes have effective openings of about 50-150 cm^2, depending on the air flow restrictions within the duct.

A fire burning at a 60 kW rate (a typical rate established by the CMHC WOODSIM program) requires about 15 l/s of stoichiometric air. An open fireplace has been shown to use up to ten times this combustion air as dilution air, giving a total flow rate of roughly 150 l/s. To supply stoichiometric air through a typical 100 mm duct, and assuming there is no additional inflow through the glass doors, the firebox would have to be depressurized to about 7 Pa relative to the outside. If it were important to maintain the 150 l/s of air, the same 100 mm duct would have to see over 700 Pa across it to create that airflow. Alternately, at a reasonable firebox depressurization of 4 Pa, it would require a duct diameter of 350 mm to supply 150 l/s of intake air. Obviously such large airflows cannot, and should not, be supplied by passive intakes.

2.1 The code requirements for fresh air intakes are only detailed in the 1986 Ontario Building Code which lists specifications for screens, dampers, the minimum duct diameter (100mm), clearance to combustibles, and fresh air intake entry to the firebox (directed away from the flame). The National Building Code states that combustion air is required, without defining the source. The Alberta Building Code requires a fresh air intake but provides no details on its construction.

The standards listed in Appendix A usually contain references to combustion air, the most specific calling for an effective combustion air intake opening equal to half of the effective flue opening. This combustion air can be room air, outside air, or a combination, except where the woodstoves or fireplaces are certified for mobile homes. Since mobile homes are considered smaller and tighter than most housing, the appliances must be run on complete outside air and are tested under more rigorous conditions of room depressurization.

ULC-S610M, the standard for Factory-Built Fireplaces, is the relevant document for most of the appliances considered in this paper. It prescribes a series of test burns - where the surface temperatures of the fireplaces, intake ducts, and the presence of spillage are monitored. For these tests, the worst possible fresh air intake locations (of those allowed by the manufacturer) are specified. For this reason the intake air to the fresh air duct has to be at a mid-summer temperature (eg. 27°c), the intake has to be structured to simulate a basement fireplace installation (intake goes up from the firebox), and the dampers must be adjusted for maximum firebox temperatures. The intake air and the intake metal surfaces are monitored for excessive temperature build-up. ULC-S627, which is the equivalent standard for woodstoves, has a simulated wind test on the fresh air intake. This is omitted in S610, even though there are other sections of both standards that are common.

Both S610- and S627 have a Part B, the test for appliances that are to be certified for mobile homes. The tests are additional to the Part A tests, that all appliances must undergo. Included in part B is a depressurization test where the room in which the appliance is located is depressurized to 17.5 pa. During the length of the burn, the room carbon monoxide level must not exceed 100 ppm. Flame roll-out or smoke spillage longer than a 15 second interval are both prohibited.

Sizing of the ducting is not addressed, except indirectly, as adequate sizing will allow fireplaces to pass these performance tests.

CSA A405, Design and Construction of Masonry Chimneys and Fireplaces, has specifications for fresh air intakes similar to that of the Ontario Code. It also has an Appendix D, which discusses the advantages and disadvantages of various fresh air intake locations around the firebox.

The R-2000 Builder Note 1, "Woodburning in Well-Sealed Houses," has fairly general advice and a list of fireplaces (and woodstoves) deemed suitable for R-2000 houses. Most of these are mobile-home certified appliances.

2.2 The research reports that dealt with fresh air intakes were quite skimpy and are listed in Appendix B. The Hatzinikolas report, "Fresh Air Intake for Fireplaces", describes testing performed on a fresh air intake design with dampers at the outside wall and firebox. The device was tested in two houses, and the procedures used in testing were quite crude. With proper instrumentation, and including flow measuring devices in the chimney, such a simple series of tests would provide interesting data for the evaluation of fresh air intakes.

The Sheltair Scientific report, describing remedial measures research for combustion spillage problems, suggested a 75 mm diameter fresh air intake when virtually airtight glass doors were retrofitted. The book by H. Morstead, "Fireplace Technology in an Energy Conscious World,"

spends four pages comparing fireplace fresh air intake options. While these publications are helpful and thought provoking, there is little hard data on the fresh air intakes flows, with or without glass doors, and under different outside wind conditions.

2.3 The other publications, in Appendix C, are equally vague, or have suggestions based on rules of thumb rather than experimentation. The RTC Engineering Consultants Ltd. letter attributes some house fires to the location of fresh air intakes to fireplaces, and contain photos of fireplaces where such incidents are said to have occurred (see Figure 1). Conversations with Dick Carlstrom make clear that this engineer has major disagreements with the ULC testing and results. Hard data on these disputed tests are not available.

A telephone interview with Bill d'Alessandro of Progressive Builder, who wrote the article "Fresh Air for Fireplaces" in Appendix C, led to similar conclusions. He stated that manufacturers that he had contacted for this article, and code officials in some states where fresh air intakes were mandated, had only cursory understanding of how and why to supply outside fresh air. Scientific research into the questions had eluded him as well.

2.4 Manufacturers' literature, listed in Appendix D, shows the range of fresh air intake designs in current use. A great number of fireplaces have simple 100mm flex duct connected at the exterior wall to a "dryer" cap and to the firebox at the front (see Figure 2). Side entry of this air, usually by a series of holes vertically aligned by the inside edge of the doors, or by holes cut in the mid-sides of the firebox (see Carlstrom drawings), is also used, though no brochures were found with this illustrated. Usually the manufacturer specifies the size of the intake ducting by the size of the collar attached to the firebox. Some of the units with glass doors have "air wash" systems that are designed to drop colder outside air by the doors to keep the glass soot free.

Figure 1: Suggested Flaws in Fresh Air Intake Design

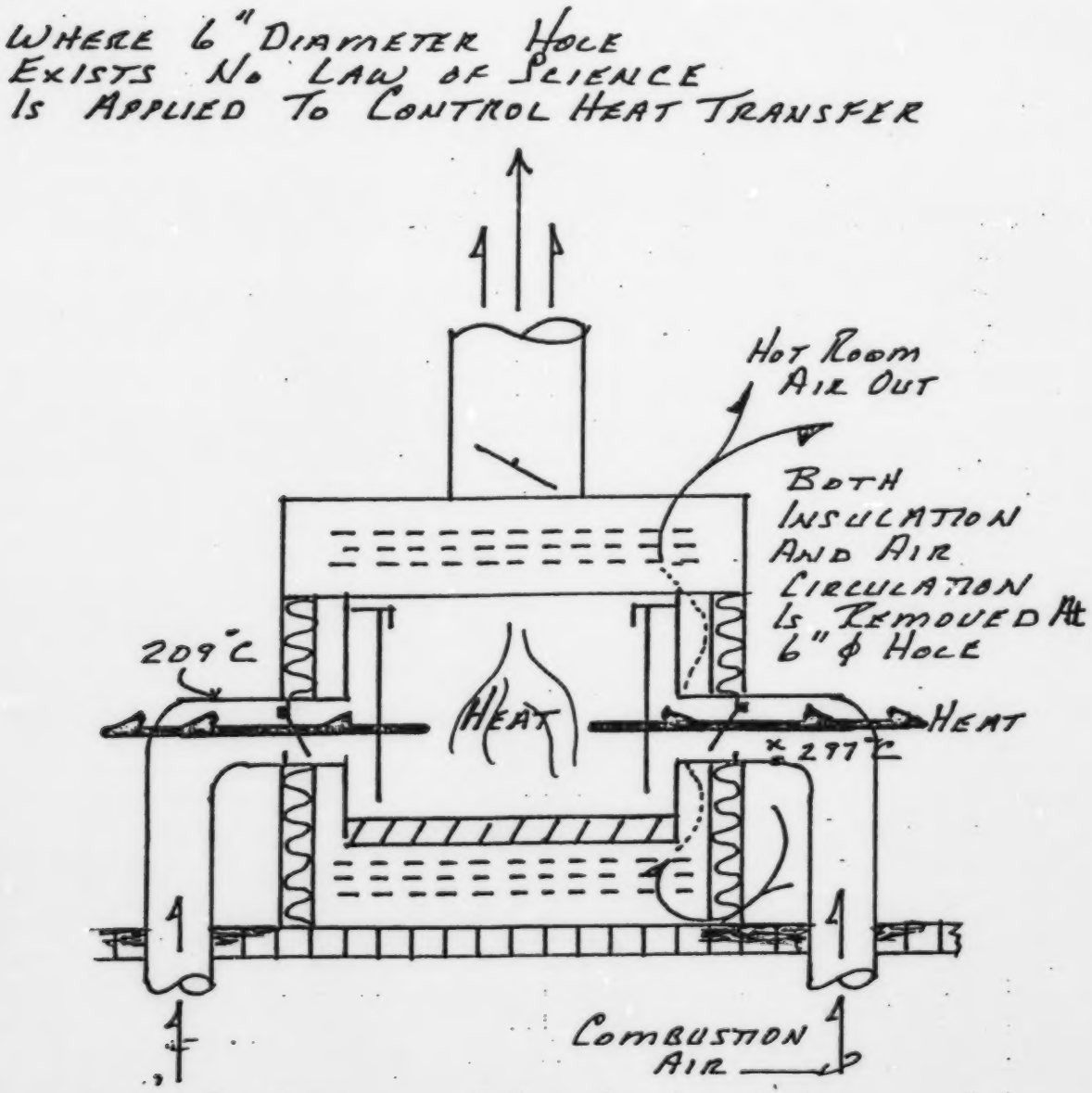


Figure 2: Typical Manufacturer's Specifications for Fresh Air Intakes

Outside Fresh Air

The fresh air control is located behind the fireplace's lower grill. Pull this lever to open.

If the optional fresh air kit is installed it must not be draw air from the attic or from the basement. The fresh air must come from outside the house.

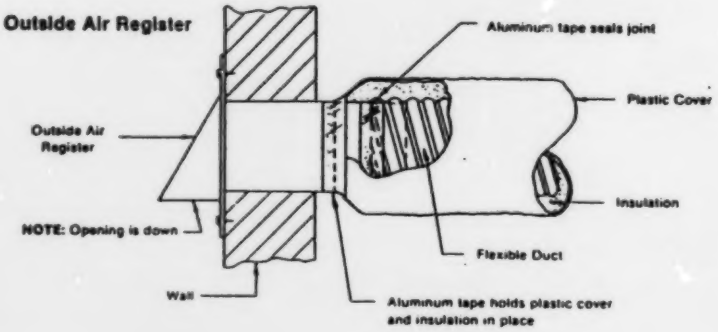
The maximum length of the air duct is 20 feet.

1 Decide on the most convenient location for the fresh air inlet duct and register. The duct and register may be installed above or below the floor level. The register must not be installed more than 7 feet above the bottom of the fireplace.

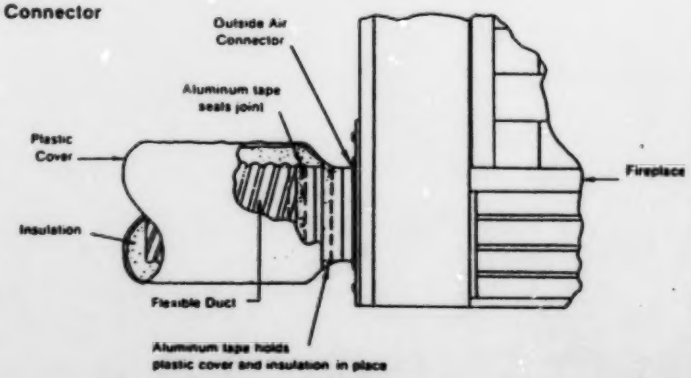
2 Make a 4-1/4" hole in an outside wall of the house. From outside, place the outside air register in the hole (open side down).

3 Place the insulated flexible duct over the register tube and over the fireplace outside air connector. At each end carefully pull back the insulation and plastic cover exposing the flexible duct. Using the aluminum tape provided, wrap the tape around the joint between the flexible duct and the air inlets. Carefully push the insulation and plastic cover back over the duct. Using the aluminum tape, fasten the plastic cover in place.

Outside Air Register



Outside Air Connector



The Fresh Air Combustion Kit extracts air from outside the home to conserve valuable interior heat. It is a more efficient and comfortable system. The flexible duct allows for simple and trouble-free connections.

Another design, seen in both the Pressurizer and Glow Boy fireplaces, uses fan-forced outside air as both circulating air to inject into the house, and as combustion air for the firebox. The general feeling, from the literature amassed and subsequent phone calls to manufacturers and designers, is that the fresh air intake systems have been designed to meet new codes and the requirements of more airtight houses. There has been little in-house research by the designers to establish the proper flow rates and sizing, or to test the designs under adverse conditions (eg. high winds, room depressurization).

CONCLUSIONS

The introduction of outside air to fireplaces, and the separation of fireplace and house air, have not been thoroughly investigated. The systems provided by manufacturers are usually rudimentary and, in some cases, could be dangerous in certain combination of house performance and weather conditions. The effectiveness of glass doors at keeping air in the firebox, and house air out of the firebox, is unknown, though preliminary testing shows that there is little resistance to air movement in standard glass doors. The ability of the fresh air intakes to supply the fireplace with adequate combustion and dilution air, under varying outside wind conditions, and with different levels of door airtightness, requires research.

There has been some attempt by manufacturers of the more expensive equipment, and fireplace inserts, to deal with these problems. Their solutions should be inspected, and examined for applicability to less costly fireplaces and retrofit situations.

REFERENCES

1. Residential Chimney Backdraft Checklist. Sheltair Scientific, for CMHC, 1984 (DRAFT).

2. Consumers' Gas Chimney Venting Performance Study. University of Toronto and Consumers' Gas limited - for EMR/BETT and the Ontario Ministry of Energy, 1986.

3. A Survey of Fireplace Spillage Incidents in Twenty Four Houses. Sheltair Scientific for CMHC, 1987.

4. Residential Combustion Venting Failure - A Systems Approach. Project 5: Remedial Measures for Wood-burning Fireplaces. Scanada Sheltair Consortium, for CMHC, 1987.

5. FIREPLACES. A Guide to Their Safe Installation and Use. ULC, 1986.

6. Personal Communication with Sebastian Moffatt, 1987.

7. National Building Code of Canada 1985. Issued by the Associate Committee on the National Building Code. NRCC No. 23174.

8. Alberta Building Code 1985. Alberta Labour, General Safety Services Division, Building Standards Branch.

9. The [Ontario] Building Code. Ministry of Housing, Buildings Branch, 1986.

10. CSA Standard B366.1 - M1981. Solid-Fuel-Fired Appliances for Residential Use. Canadian Standards Association, 1981.

11. CSA B365-M84 (National Standard of Canada). Installation Code for Solid Fuel Burning Appliances and Equipment. Canadian Standards Association, 1984.

12. ULC-S627. Standard for Space Heaters for Use with Solid Fuels (Second draft, proposed fourth edition). Underwriters' Laboratories of Canada, 1986.

13. ULC-S610M. Standard for Factory-Built Fireplaces (Second draft, proposed sixth edition). Underwriters' Laboratories of Canada, 1986.

14. ULC-S628-M1982. Standard for Fireplace Inserts. Underwriters' Laboratories of Canada, 1982.

15. CSA A405. Design and Construction of Masonry Chimneys and Fireplaces (Third draft). Canadian Standards Association, 1986.

16. R-2000 Builder Notes. Number 1. Woodburning in Well-sealed Houses. EMR/CHBA, 1986.

17. Fireplace Technology in an Energy Conscious World. H. Morstead, Centre for Research and Development in Masonry, 1981.

18. Fresh Air Intake for Fireplaces. Dr. M. A. Hatzinikolas, for the Alberta Department of Housing, 1984.

19. Investigation of Fire Hazards of Fireplace Inserts in Factory-Built and Masonry Fireplace. Terpstra, Jorgenson, and Dosedlo; Underwriters Laboratories Inc., 1982.

20. Wood Burning Simulator. User's Manual (DRAFT) Scanada Consultants, for CMHC, 1987.

21. How to Build a Safer Fireplace. Habitation, February/March, 1984.

22. Unlikely Housemates: Can the Traditional Masonry Fireplace Coexist with Super Energy Efficient Housing Technology. John Archer; Habitation, February/March, 1986.

23. Fresh Air for Fireplaces. Bill d'Alessandro; Progressive Builder, April, 1987.

24. ULC-638M. Standard for Glass Screens for Masonry Fireplaces (First draft, proposed first edition). Underwriters' Laboratories of Canada, 1984.

25. Research on the Energy Efficiency of Fireplaces. William M. Phillips, for U.S. Department of Energy, 1982.